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⑭定方向組織配列鋳物の鋳造法

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明　細　書

1. 発明の名称

定方向組織配列鋳物の鋳造法

2. 特許請求の範囲

(1) 鋳型加熱炉内に上昇下降可能に設置したセラミック鋳型を溶解母材の凝固温度以上に加熱し、該鋳型中に別に溶解した該溶解母材を注湯し、該鋳型内の該湯の静止を待つて該鋳型を該鋳型加熱炉直下の冷却機構を備えた流動床冷却槽内の該湯と反応しない高融点物質の粉体と底部のガス透過板より吹き込まれる不活性ガスとによつて形成される流動層中を徐々に降下させ、該湯の凝固を完成させることを特徴とする定方向組織配列鋳物の鋳造法。

3. 発明の詳細な説明

本発明は鋳型中の湯に急激な縦方向の温度勾配を与えるとともに横方向の温度勾配を抑え、それによつて製品組織の乱れを発生させることのない定方向組織配列鋳物の鋳造法に関する。

たとえば、タービンブレードやベーンのごとき高温高応力下で使用されるガスタービン部材を構成する定方向組織配列鋳物の鋳造法には次のごときものがある。

(1) パワーダウン法

この方法は鋳型底部の金属製水冷板と分割された鋳型加熱ヒーターを下部より順次コントロールすることにより得られる温度勾配下で凝固を進行させる方法であるが、欠点は凝固速度がおそいので能率が悪いことである。

(2) 高速凝固法(特許第486830号)

この方法は水冷金属底部を有する鋳型を加熱帯より順次引き出し凝固を進行させる方法であるが、欠点は凝固方向に横方向(円周方向)の温度勾配が生じることである。

(3) LMC法

この方法は底部閉鎖鋳型に注湯後、該鋳型を加熱帯から低融点金属液体(鉛、スズ等)中に一方向に投入する方法であるが、欠点は液体金属などを冷媒として使用するので湯との接触などにより該液体金属が汚染原因となることである。

(4) ソ連法（特開昭49－130320号公報）

この方法は底部閉鎖鋳型に注湯後、これに水冷却板を接触させた後、加熱帯から引き出す方法であるが、(2)の高速凝固法と同じ欠点を有する。

本発明は上記の従来法の欠点を解決し、鋳型中の湯に急激な縦方向の温度勾配を与えるとともに横方向の温度勾配を抑え、それによつて製品組織の乱れを発生させることのない定方向組織配列鋳物の鋳造法を提供するもので、その要旨とするところは、鋳型加熱炉内に上昇下降可能に設置したセラミック鋳型を溶解母材の凝固温度以上に加熱し、該鋳型中に別に溶解した該溶解母材を注湯し、該鋳型内の該湯の静止を待つて該鋳型を該鋳型加熱炉直下の冷却機構を備えた流動床冷却槽内の該湯と反応しない高融点物質の粉体と底部のガス透過板より吹き込まれる不活性ガスとによつて形成される流動層中を徐々に降下させ、該湯の固化を完成させることを特徴とする定方向組織配列鋳物の鋳造法、にある。

次に、本発明を図面によつて説明する。

第1図は本発明の実施に使用される装置系統図の一例、第2図(a)は本発明によつて得られた鋳物の一例の良好な組織を示す顕微鏡写真、同じく(b)は従来技術による鋳物の組織の乱れを示す顕微鏡写真である。第2図(a)，(b)の横軸は凝固方向を示す。

第1図において、グラファイトサセスセプター4を備えた鋳型加熱炉11内に上昇下降可能に設けたセラミック鋳型5を注湯対象の溶解母材の凝固温度以上に高周波加熱装置14により加熱する。この加熱された鋳型5に別に設けられた溶解炉2にて溶解された溶解母材を注湯する。鋳型5内での湯の対流や渦流の静止するのを待つて、鋳型昇降機1の駆動により鋳型5を鋳型加熱炉11直下の水冷コイル6を備えた流動床冷却槽12内の流動層中に徐々に縦方向の温度勾配をつけながら降下投入する。この流動層は該湯との直接接触が生じた場合でも反応を起こさない安定な高融点物質の粉体7とガス圧力タンク室9から底部のガス透過板8を通して均一に吹き込まれる不活性ガス13、たとえばアルゴン、ヘリウム等とによつて形成されるものである。すなわち、不活性ガス13の圧力、流量の調整により粉体7を上昇させて流動化状態とし、鋳型5をこの流動化状態の粉体7中に抵抗なく徐々に降下投入させることができる。流動層内では徐々に降下する鋳型5に縦方向の急激な温度勾配を与え、流動粉体7は鋳型5の下部に一様に接触するので該湯の一方向の固化を容易ならしめるとともに流動粉体7が鋳型5の外壁間にも進入するので横方向の温度勾配を最小限に抑える。鋳型5の流動層中への降下投入は該湯の固化が完了するまで進行させ操作を完了する。

本発明の効果は次の通りである。

(1) 冷却系は加熱系と完全に分離しており、注湯前は鋳型を均一に加熱することができ、注湯後の冷却槽内への鋳型の降下投入により、湯の渦流、対流の静止したときをみはからつて所望の時に均一な核生成をさせることができる。従つて、従来技術のパワーダウン法、高速凝固法におけるごとく、注湯と同時の凝固開始という不便さがない。

(2) 従来技術の高速凝固法、ソ連法はサスセプター内から鋳型と冷却板を引出すことにより、主に輻射により放熱し、固化を進行させるが、本発明では冷却流動粉体を直接接触させることにより、鋳型から熱を抽出するため、急激な温度勾配が得られ、従つて固化速度を大きくすることができる。　また、従来技術の高速凝固法、ソ連法では鋳型が大きくなり、いわゆるクラスターモールドの場合、外周壁は急速に冷却されても中央部は熱だまりとなり、横方向（円周方向）に温度勾配がつき易く、第2図(b)に示すように、製品組織の乱れを出現させ易い。その結果、製品の機械的強度、引張り強度、熱疲労、クリープ強度が減少する。これに対し、本発明では上記粉体がこの熱だまりも自由に流動するので横方向の温度勾配を最小におさえることができ、そのため得られる製品の組織は第2図(a)に示すようにきわめて良好である。

(3) 従来技術のLMC法では溶解金属を冷却体とするため、鋳型が破損した場合や壁面流動によ

り製品中に混合することがあるが、本発明ではそのようなことは発生しない。

本発明は、以上のごとく、鋳型中の湯に急峻な縦方向の温度勾配を与えるとともに横方向の温度勾配を抑え、それによつて製品組織の乱れを発生させることのない定方向組織配列鋳物の鋳造法を提供するもので、高温高応力下で使用されるガスタービン部材製造上きわめて有用である。

4. 図面の簡単な説明

第1図は本発明の実施に使用される装置系統図の一例、第2図(a)は本発明によつて得られた鋳物の一例の良好な組織を示す顕微鏡写真、同じく(b)は従来技術による鋳物の組織の乱れを示す顕微鏡写真である。第2図(a),(b)において横軸は凝固方向を示す。

図において、

1 …鋳型昇降機
2 …溶解炉
3 …鋳型支持治具
4 …グラファイトサスセプター
5 …鋳型
6 …水冷コイル
7 …粉体(流動媒体)
8 …ガス透過板
9 …ガス圧力タンク室
11 …鋳型加熱炉
12 …流動床冷却槽
13 …不活性ガス
13a …不活性ガスボンベ
14 …高周波加熱装置

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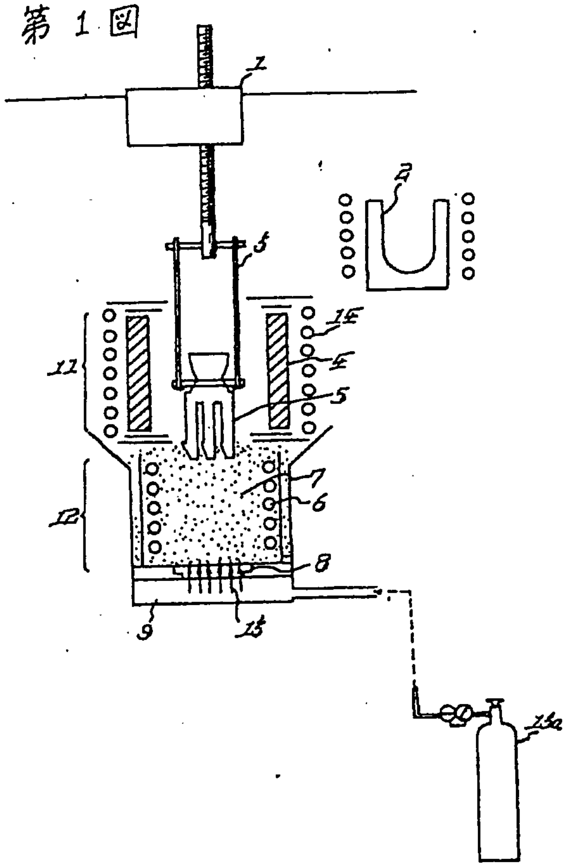
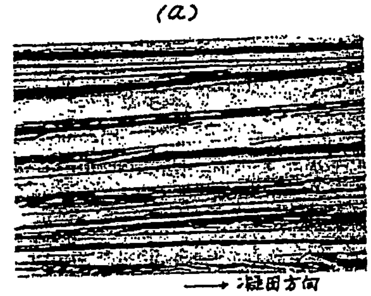
第1図



第2図

(a)



(b)

(19) Japan Patent Office (JP)
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(54) METHOD FOR CASTING OF CASTINGS WITH UNIDIRECTIONAL STRUCTURE ORIENTATION

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Specification

1. Title of the Invention

METHOD FOR CASTING OF CASTINGS WITH UNIDIRECTIONAL STRUCTURE ORIENTATION

2. Patent Claims

(1) A method for casting of castings with unidirectional structure orientation comprising the steps of heating a ceramic mold disposed inside a mold heating furnace so that it can be raised and lowered to a temperature no less than the solidification temperature of a molten base material, pouring said molten base material that was separately melted into said mold to obtain a melt bath, gradually lowering said mold, once a stationary state of said melt bath inside said mold has been attained, through a fluidized bed formed by a powder of a substance with a high melting point which does not react with said melt bath inside a fluidized bed cooling apparatus equipped with a cooling mechanism directly below said mold heating furnace and an inert gas blown from a gas permeable plate disposed in the bottom portion, and completing the solidification of said melt bath.

3. Detailed Description of the Invention

The present invention relates to a method for casting of castings with unidirectional structure orientation in which the disturbance of the product structure is prevented by providing a melt bath in a mold with large temperature gradient in the longitudinal direction, while suppressing the temperature gradient in the lateral direction.

For example, the following methods have been used for casting of castings with unidirectional structure orientation, such as gas turbine parts employed at a high temperature and under a high stress, for example, turbine blades and vanes.

(1) Power down method

With this method, solidification is advanced under a temperature gradient obtained by successively controlling a mold heater on the underside thereof, this mold heater being separated from a metallic water-cooled plate located at the mold bottom. The drawback of this method was that the solidification rate was low which resulted in a poor efficiency.

(2) Rapid solidification method (Japanese Patent No. 486830)

With this method, solidification is advanced by successively pulling a mold having a water-cooled metallic bottom from a heating zone. The drawback of this method was that the temperature gradient in the lateral direction (tangential direction) appeared in the solidification direction.

(3) LMC method

With this method, once pouring of a melt into a bottom-sealed casting mold has been completed, the mold is unidirectionally introduced from a heating zone into a liquid metal with a low melting point (lead, tin, and the like). The drawback of this method was that a liquid metal was used as a coolant and therefore the liquid metal could become a source of contamination when it was brought in contact with the melt bath.

(4) Russian method (Japanese Patent Application Laid-open No. 49-130320)

In accordance with this method, once pouring of a melt into a bottom-sealed casting mold has been completed, a water-cooled plate is brought in contact thereto and the melt is pulled out from a heating zone. This method has the same drawbacks as the above-described method (2).

It is an object of the present invention to resolve the above-described problems and to provide a method for casting of castings with unidirectional structure orientation in which the disturbance of the product structure is prevented by providing a melt bath in a mold with a large temperature gradient in the longitudinal direction, while suppressing the temperature gradient in the lateral direction. Thus, the present invention provides a method for casting of castings with unidirectional structure orientation comprising the steps of heating a ceramic mold disposed inside a mold heating furnace so that it can be raised and lowered to a temperature no less than the solidification temperature of a molten base material, pouring the molten base material that was separately melted into the mold to obtain a melt bath, gradually lowering the mold, once a stationary state of the melt bath inside the mold has been attained, through a fluidized bed formed by a powder of a substance with a high melting point which does not react with the melt bath inside a fluidized bed cooling apparatus equipped with a cooling mechanism directly below the mold heating furnace and an inert gas blown from a gas permeable plate disposed in the bottom portion, and completing the solidification of the melt bath.

The present invention will be described below with reference to the drawings attached.

Fig 1 schematically represents an apparatus used for the implementation of the present invention. Fig 2(a) is a microscope image illustrating an example of good structure of a casting obtained in accordance with the present invention. Fig 2(b) is a microscope image illustrating structure disturbance in the casting obtained by the conventional technology. The horizontal axis in Figs 2(a) and (b) shows a crystallization direction.

In Fig 1, a ceramic mold 5 disposed inside a mold heating furnace 11 equipped with a graphite susceptor 4 so that it can be raised and lowered is heated with a high-frequency heating apparatus 14 to a temperature no less than the crystallization temperature of a molten base material which is the object of casting. The molten base material that has been melted in a separately provided melting furnace 2 is poured into the heated mold 5 to form a melt bath. Once a stationary state of the melt bath (without convection or vortexes) inside the mold has been attained, the mold 5 is lowered and introduced, while a temperature gradient in the longitudinal direction is being gradually provided thereto, into a fluidized bed inside a fluidized bed cooling apparatus 12 provided with a water-cooled coil 6 and located directly below the mold heating furnace 11. This fluidized bed is formed by a powder 7 of a stable substance with a high melting point which causes no reaction with the melt bath even when it is brought in direct contact therewith and an inert gas 13, such as argon, helium, and the like, which is uniformly blown from a gas pressure tank chamber 9 through a gas permeable plate 8 located in the bottom portion. Thus, the powder 7 is raised and fluidized by adjusting the pressure and flow rate of the inert gas 13, and the mold 5 can be gradually lowered and introduced, without resistance, into the powder 7 in a fluidized state. Inside the fluidized bed, a significant temperature gradient in the lateral direction is provided to the mold 5 and the fluidized powder 7 is brought in uniform contact with the lower portion of the mold 5. As a result, unidirectional solidification of the melt bath is readily induced. Moreover, since the fluidized powder 7 penetrates between the outer walls of the mold 5, temperature gradient in the lateral direction can be held to a minimum. Lowering and introduction of the mold 5 into the fluidized bed is continued till the solidification of the melt bath is completed.

The effect of the present invention is described below.

(1) The cooling system is completely separated from the heating system. The mold can be uniformly heated before the melt is poured into the mold. Homogeneous nucleation can be induced in a desired period by lowering the mold into a cooling apparatus after the melt was poured therein, if a stationary state is selected in which convection and vortexes in the melt bath are eliminated. Therefore, initiation of solidification during pouring of the melt, which was typical for the power down method and rapid solidification method representing the conventional technology, is avoided.

(2) With the rapid solidification method and Russian method representing the conventional technology, the mold and the cooling apparatus are pulled out from a susceptor. Therefore, heat emission and solidification are advanced mainly by radiation. By contrast, in accordance with the present invention, heat is extracted from the mold by means of direct contact with a cooling fluidized powder. Therefore, a large temperature gradient can be obtained. As a result, the solidification rate can be increased. Furthermore, when the mold had a large size and the so-called cluster mold was used within the framework of the rapid solidification method and Russian method representing the conventional technology, even if the outer walls were rapidly cooled, the central portion remained hot. As a result, a temperature gradient easily occurred in the lateral direction (tangential direction) and a disturbance of product structure shown in Fig 2(b) could be easily observed. As a result, mechanical strength, tensile strength, thermal fatigue strength, and creep strength of the product degraded. By contrast, in accordance with the present invention, the temperature gradient in the lateral direction can be held to a minimum. Therefore, a very good structure of the product shown in Fig 2(a) can be obtained.

(3) With the LMC method representing the conventional technology, a molten metal is used as a cooling medium. As a result, when the mold is broken or because of wall surface flow, the molten metal can be mixed with the product. No such problem is associated with the method in accordance with the present invention.

As described above, the present invention provides a method for casting of castings with unidirectional structure orientation in which the disturbance of the product structure is prevented by providing a melt bath in a mold with a large temperature gradient in the longitudinal direction, while suppressing the temperature gradient in the lateral direction. Accordingly, the present invention is very useful for the manufacture of gas turbine parts employed at a high temperature and under a high stress.

4. Brief Description of the Invention

Fig 1 schematically represents the apparatus used for the implementation of the present invention. Fig 2(a) is a microscope image illustrating an example of good structure of the casting obtained in accordance with the present invention. Fig 2(b) is a microscope image illustrating structure disturbance in the casting obtained by the conventional technology. The horizontal axis in Figs 2(a) and (b) shows a crystallization direction.

[Legends]

1 – apparatus for raising and lowering a mold
2 – melting furnace
3 – mold support
4 – graphite susceptor

5 – mold
6 – water-cooled coil
7 – powder
8 – gas-permeable plate
9 – gas pressure tank chamber
11 – mold heating furnace
12 – fluidized bed cooling apparatus
13 – inert gas
13a – inert gas cylinder
14 – high- frequency heating apparatus.

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Fig 1

Fig 2
Solidification direction
Solidification direction